Universidad del País Vasco / Euskal Herriko Unibertsitatea

Technical workshop.

Benjamín Tapia (ESR11).

Intelligent Robotic System for Physical Interaction Tasks

21/06/23

EUROPEAN TRAINING NETWORK ON
MONITORING LARGE-SCALE COMPLEX SYSTEMS
MOIRA

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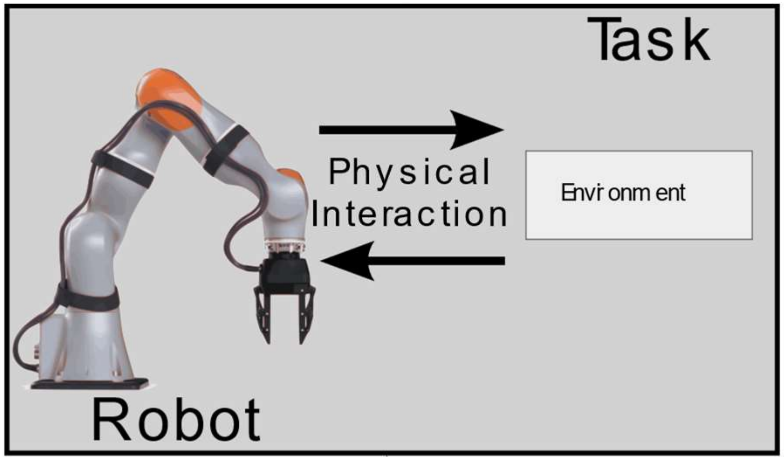
index

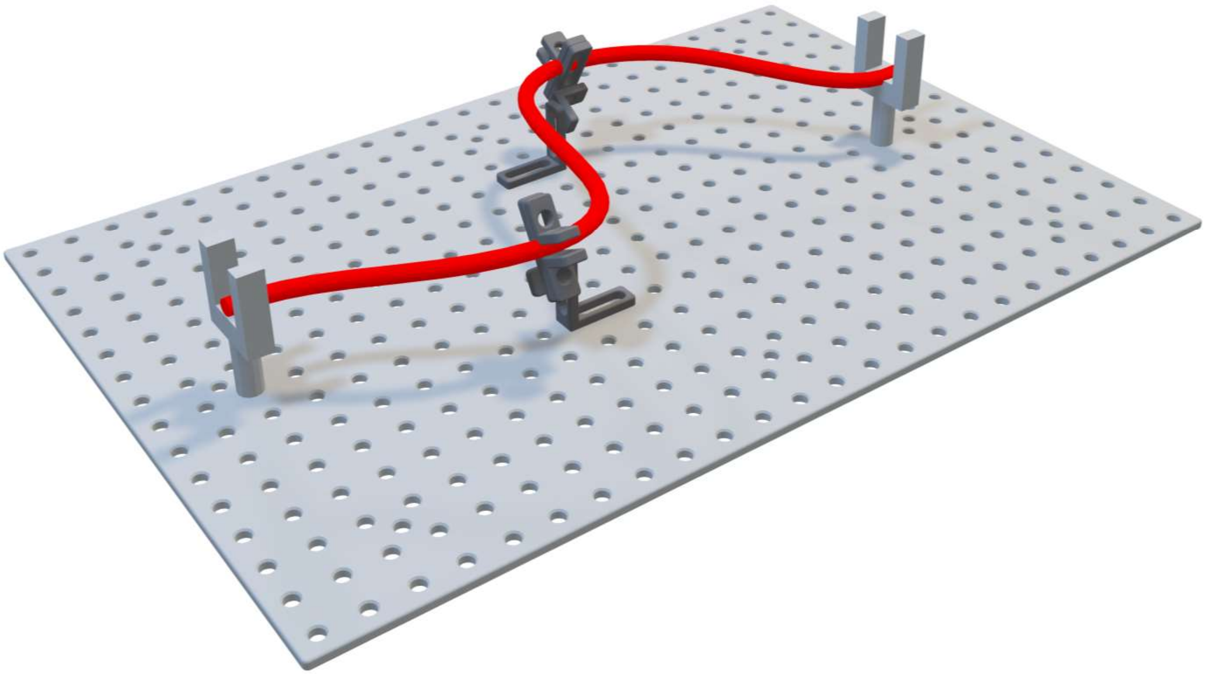
1. Proposal

Disassembly

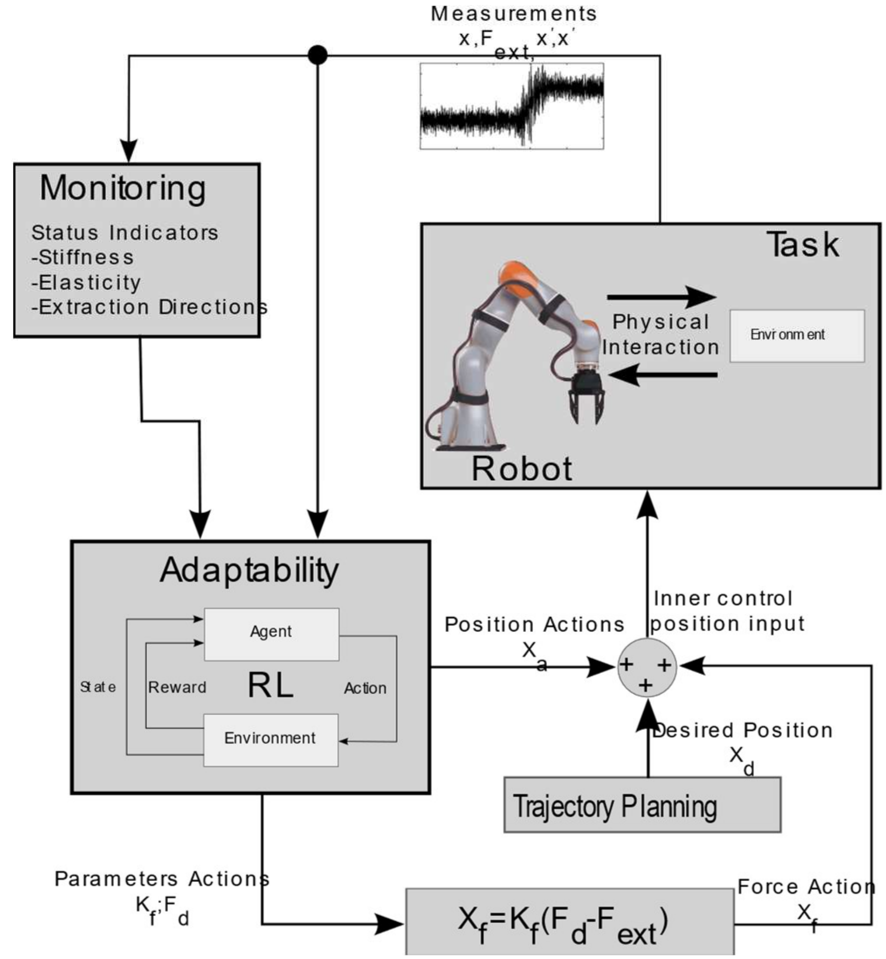
Of flexible elements

- Case of uses
- Challenges





Proposal.



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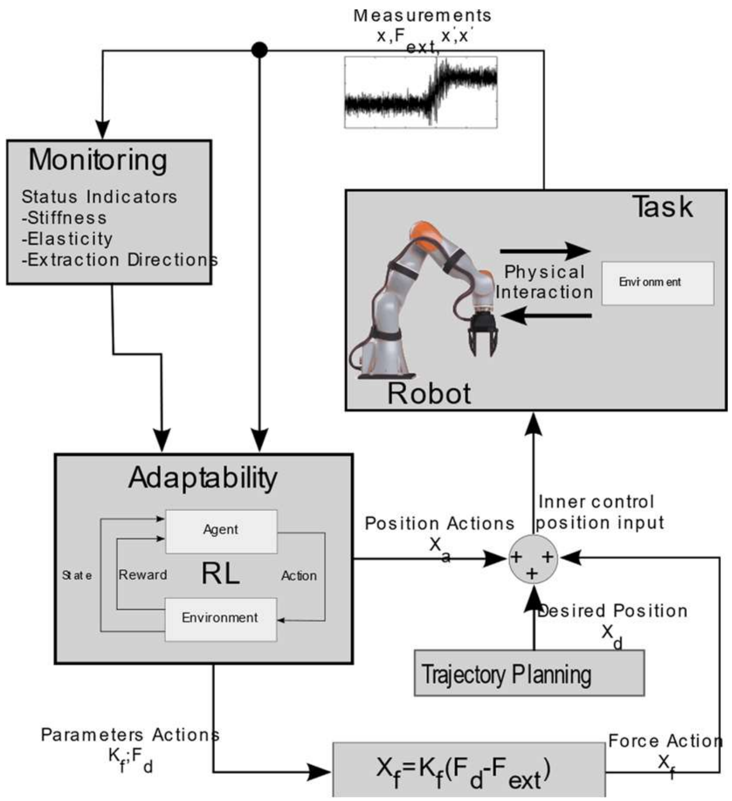
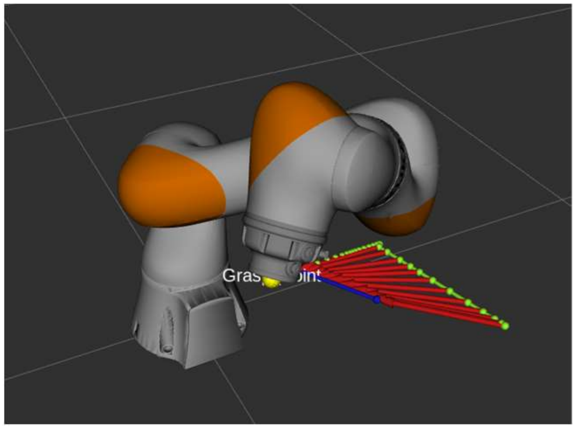
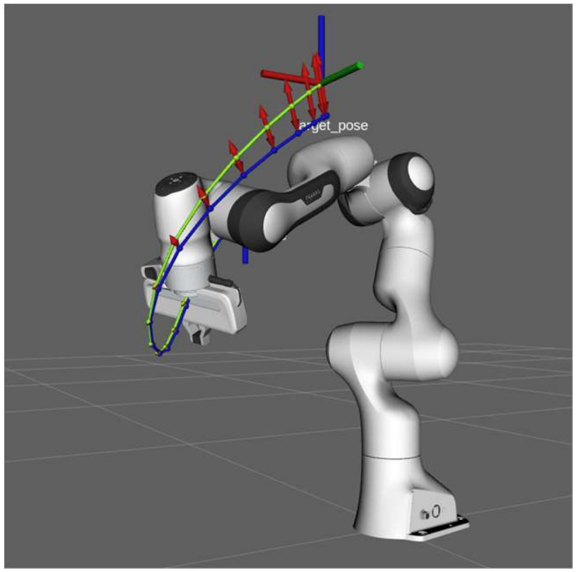
1. Proposal



Measurements
x,F ext, x',x''
Monitoring
Status Indicators
-Stiffness
-Elasticity
-Extraction Directions
Task
Physical Interaction
Environment
Robot
Adaptability
Agent
State
Reward
RL
Action
Environment
Position Actions
Xa
Inner control
position input
Desired Position
Xd
Trajectory Planning
Parameters Actions
Kf;Fd
Xf=Kf(Fd-Fext)
Force Action
Xf





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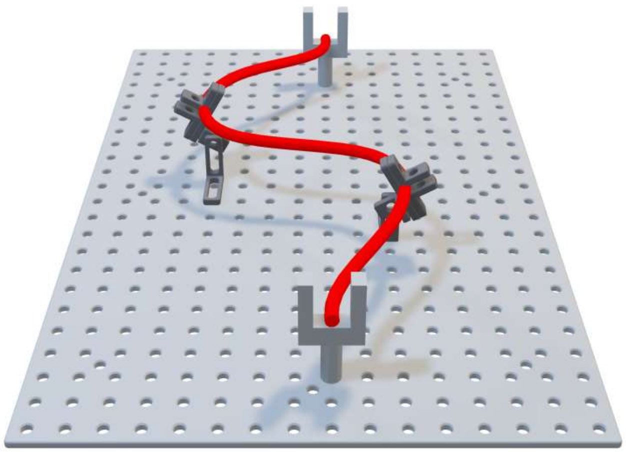

Validation Environment

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Current Work.

1 Monitoring System

2 Adaptive system

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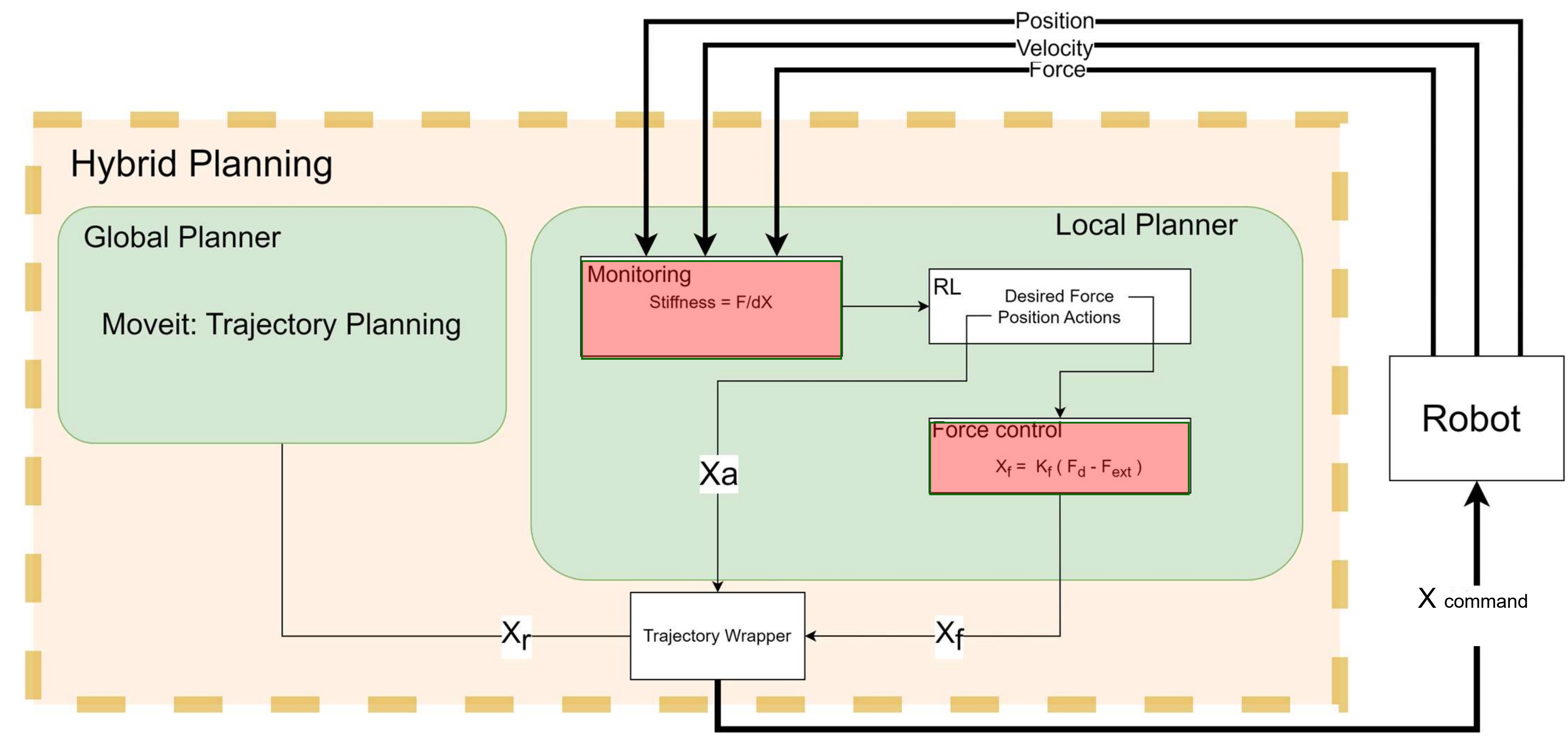
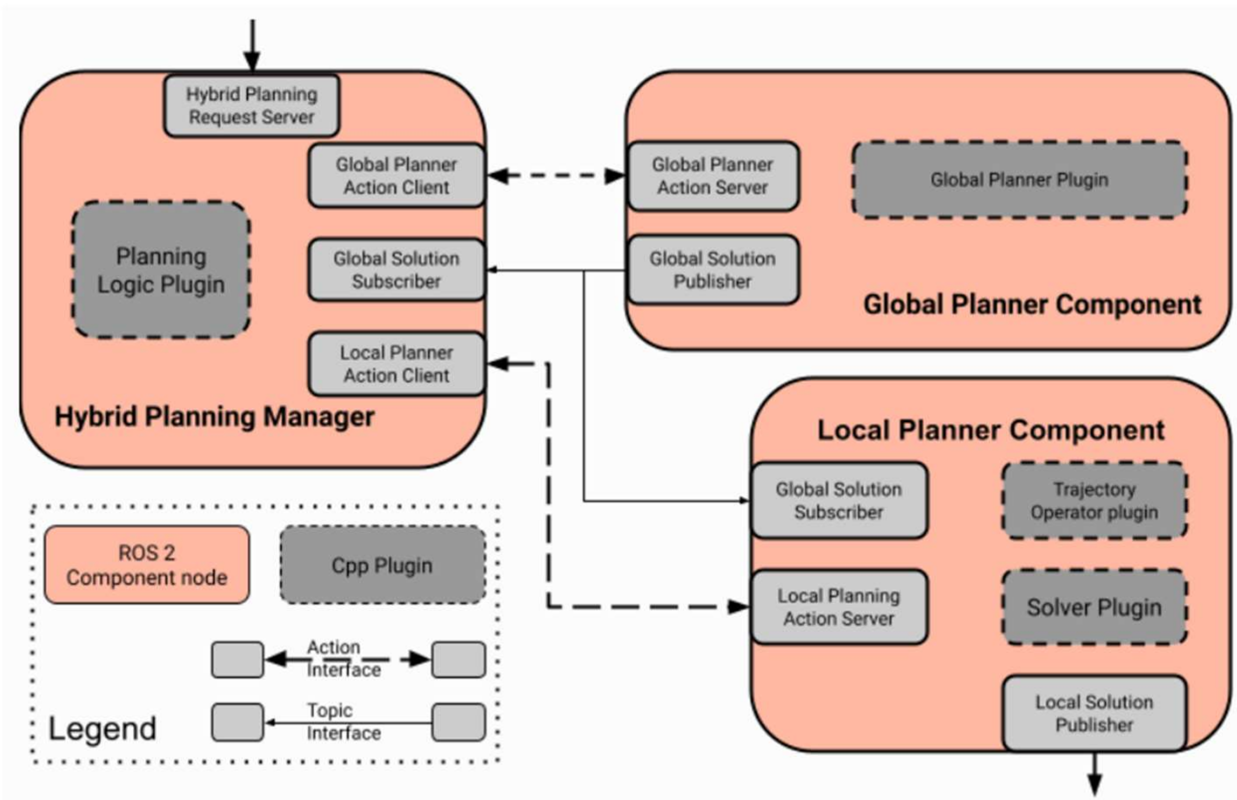
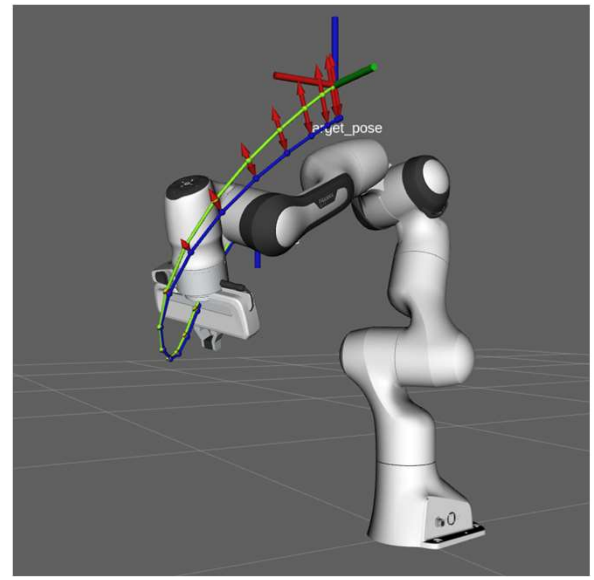


Hybrid Planning Framework

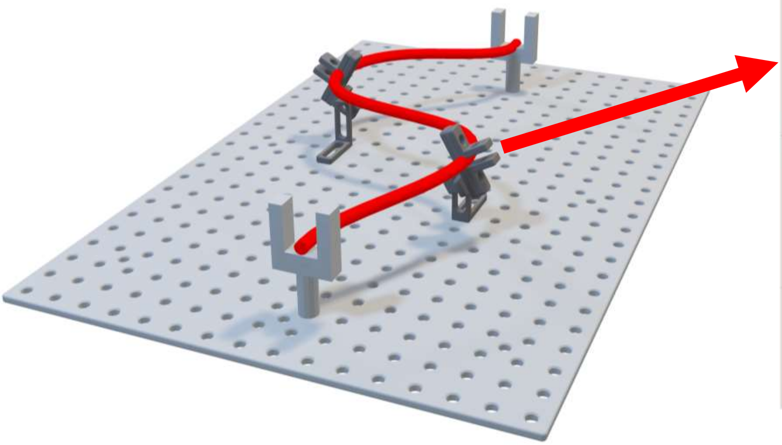
Implementations

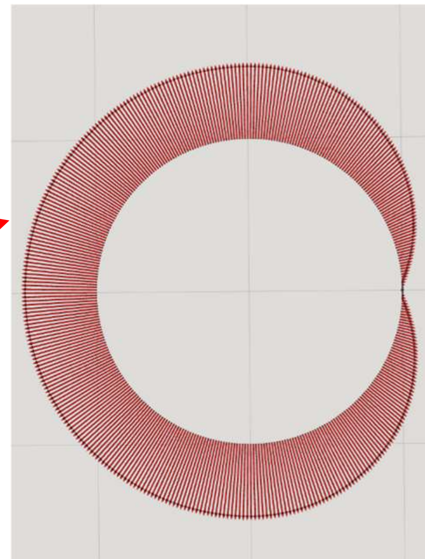
3. Implementations

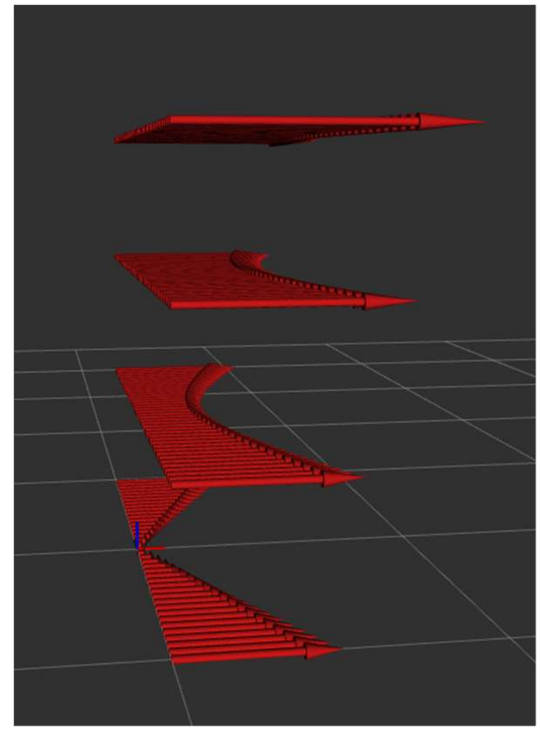




3. Implementations







Force Simulation

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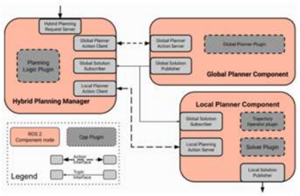
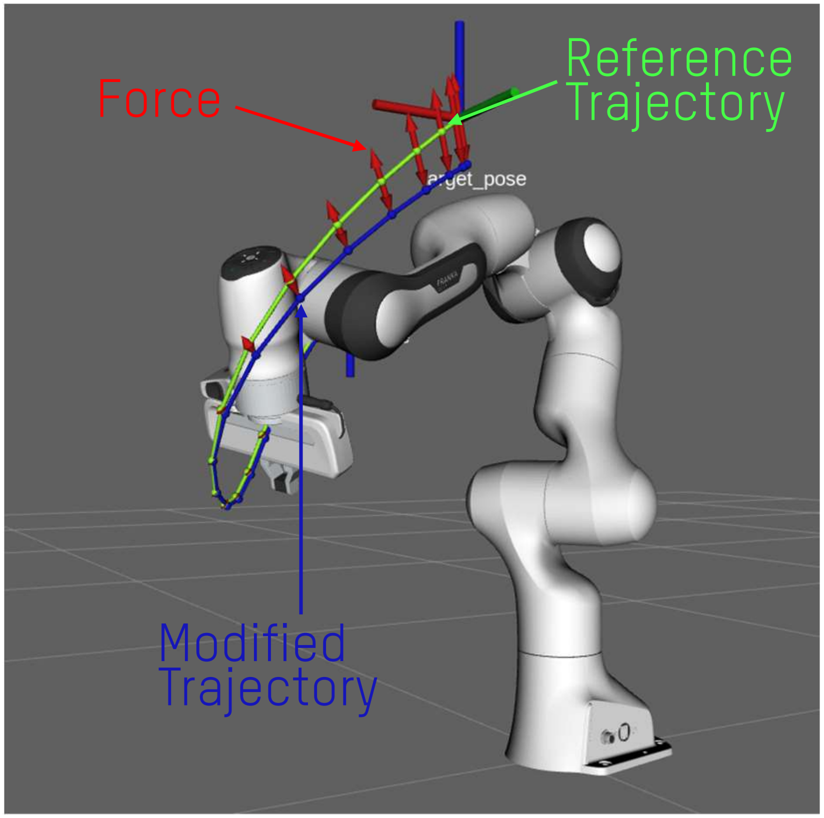
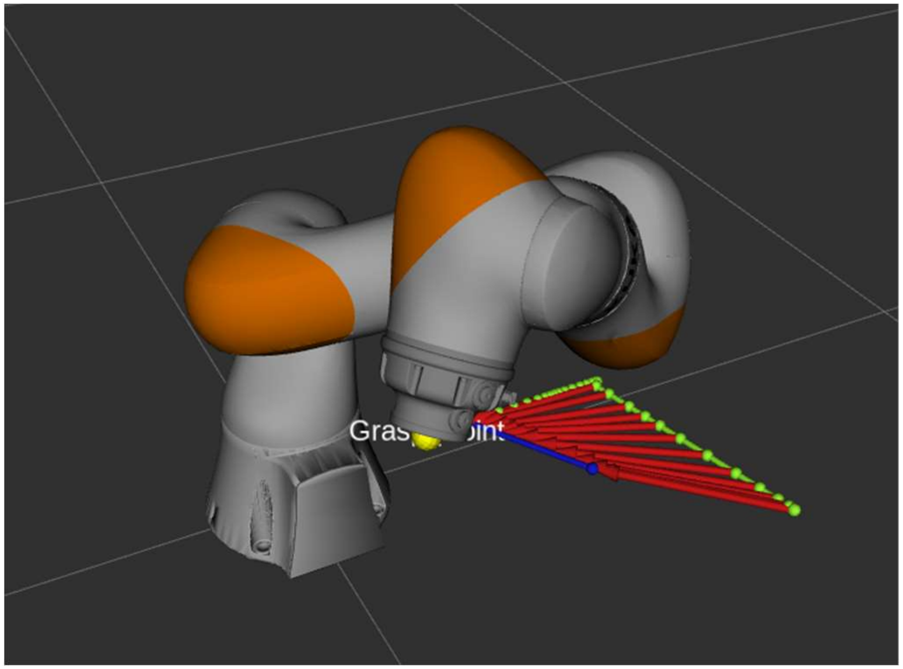
3. Implementations







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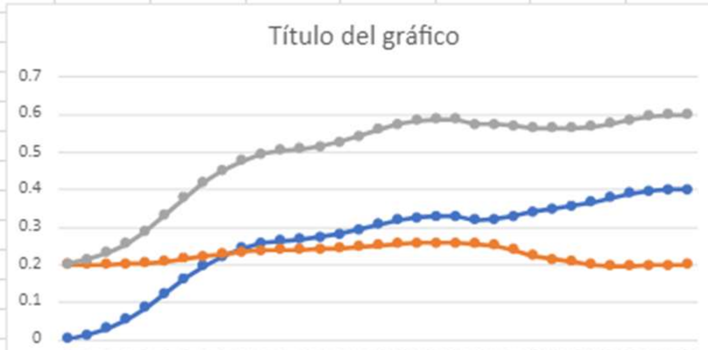
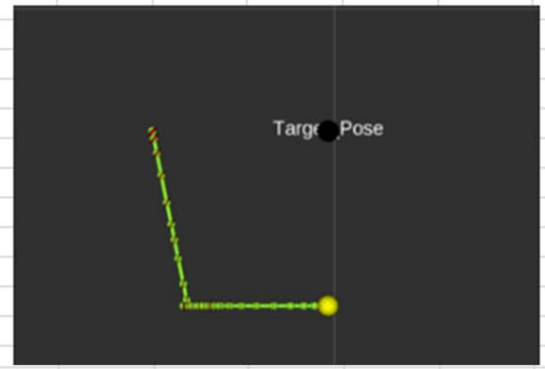
0.0137409	0.200115	0.213856
0.0309227	0.200594	0.231517
0.054979	0.201879	0.256858
0.0858359	0.204552	0.290388
0.123202	0.209272	0.332474
0.163261	0.216018	0.37928
0.196783	0.222892	0.419675
0.223478	0.229096	0.452574
0.243675	0.234186	0.477862
0.257466	0.237845	0.495311
0.264817	0.239855	0.504672
0.268377	0.240855	0.509233
0.273387	0.242261	0.515648
0.281777	0.244652	0.526429
0.294128	0.248258	0.542386





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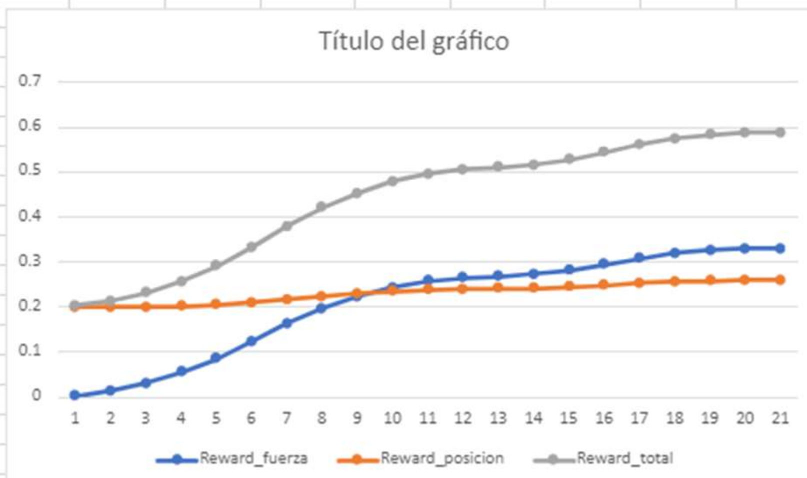

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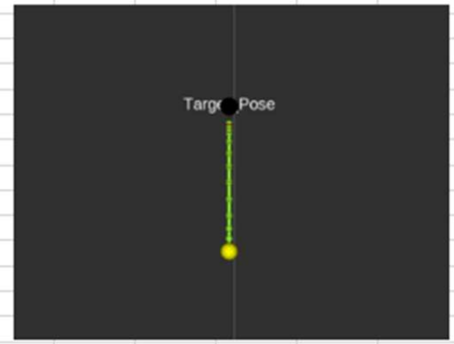
0.000022315	0.168642	0.168664
0.000029739	0.150679	0.150709
3.99956E-05	0.128559	0.128599
5.16649E-05	0.104792	0.104844
6.19903E-05	0.0833704	0.0834324
6.87445E-05	0.0649253	0.064994
7.19332E-05	0.0493066	0.0493785
0.000071812	0.0369126	0.0369844
7.02215E-05	0.0288373	0.0289075
0.000049454	0.024966	0.0250155
9.02997E-08	0.0244445	0.0244445



Reward_fuerza	Reward_posicion	Reward_total
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0.0140549	0.20701	0.221065
0.0311113	0.215538	0.24665
0.0539851	0.226976	0.280961
0.0815947	0.240782	0.322376
0.112813	0.256393	0.369205
0.144314	0.272146	0.41646
0.169664	0.284824	0.454488
0.189318	0.294653	0.483972
0.203873	0.301933	0.505806
0.21364	0.306818	0.520458
0.219534	0.309763	0.529297
0.224048	0.312002	0.53605
0.229528	0.314742	0.54427
0.239006	0.319482	0.558488
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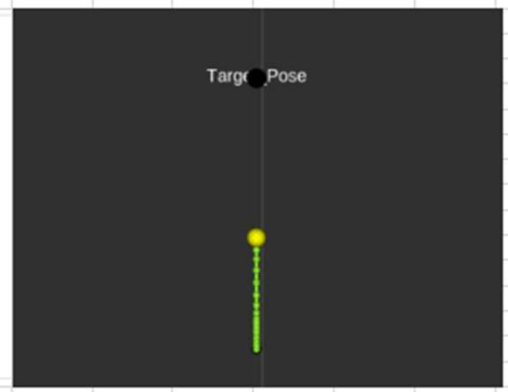

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0.000071812	0.0369126	0.0369844
0.0185745	0.0363869	0.0549614
0.0744233	0.047789	0.122212
0.164091	0.0848461	0.248937
0.232923	0.117444	0.350367
0.26709	0.134082	0.401172
0.294644	0.14762	0.442263
0.346627	0.173365	0.519991
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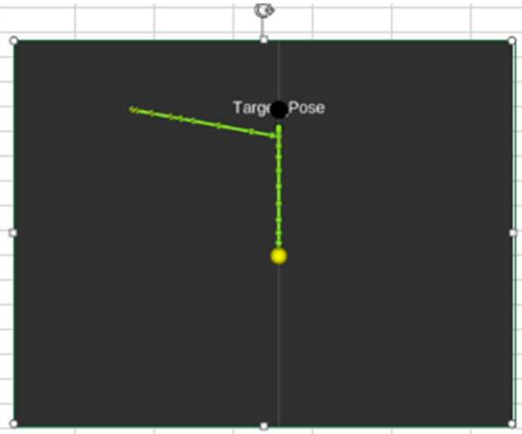
0.4	0.2	0.6



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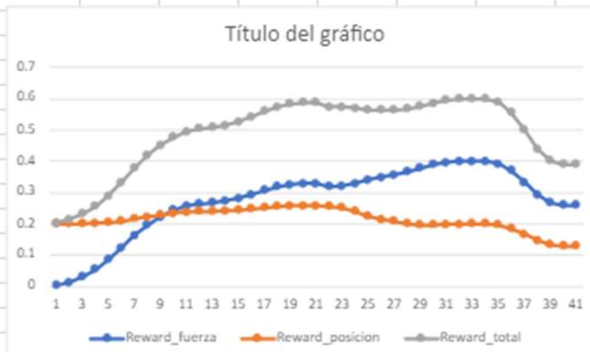
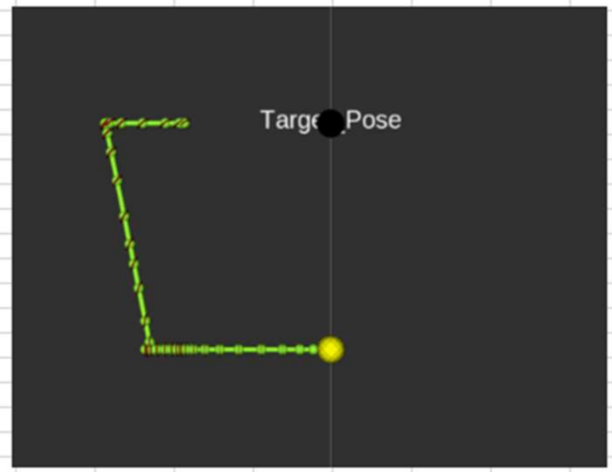
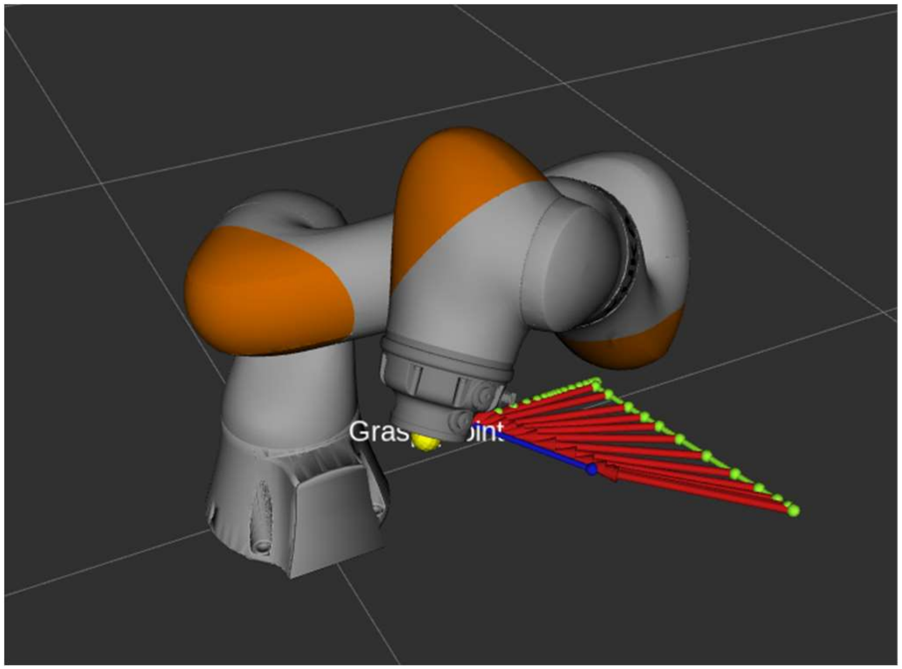


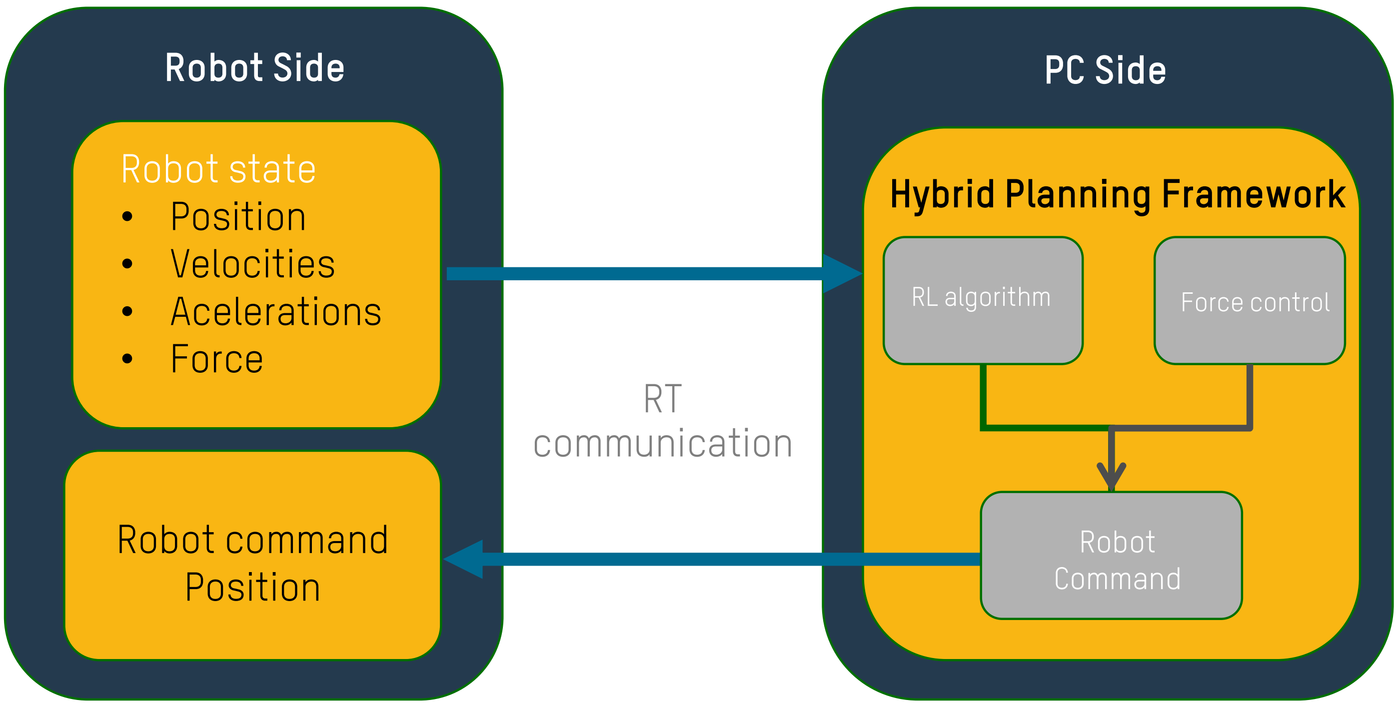


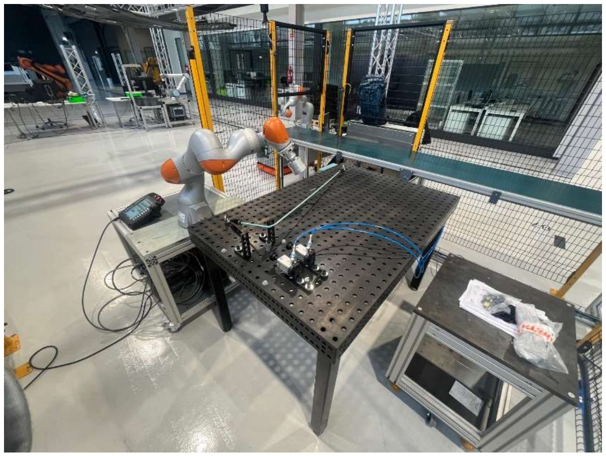
Real world implementation



SENSE ⇄ ACT

Real world implementation





FRI

LBR FRI ROS2 Stack

ROS2 packages for the KUKA LBR, including communication to the real robot via the Fast Robot Interface (FRI), MoveIt2 integration and Gazebo simulation support. Included are the `iiwa7`, `iiwa14`, `med7`, and `med14`. To get going, follow the First Steps.

2 Product description

2.1 Overview of Sunrise.FRI

FRI is an interface via which data can be exchanged continuously and in real time between a robot application on the robot controller and an FRI client application on an external system.

The real-time capability provides the FRI client application with fast cyclical access to the robot path at millisecond intervals.

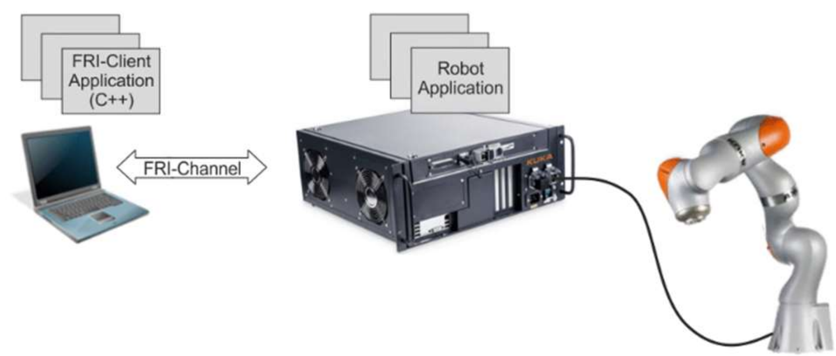


Fig. 2-1: Overview of application development with FRI

Future work and Publications

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4. Next Steps

1 Simulation: Comparisson analisys between SoA implementation and our proposal

2 Real environment: Migrate from Franka robot to kuka iiwa
Real robot setup and implementations

3 Self-adaptation: RL algorithms comparisson

- Full integration Hybrid-planning
- Hardware interface with RL
- Evaluation

5. Publications

IEEE-IRC

Intelligent Adaptative Robotic System for Physical Interaction Tasks

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2nd Gorka Sorrosal, *Ikerlan Technology Research Centre*, Arrasate, Spain, gsorrosal@ikerlan.es
3rd Aitziber Mancisidor, *Faculty of Engineering in Bilbao, University of the Basque Country (UPV/EHU)*, Bilbao, Spain, aitziber.mancisidor@ehu.eus

***Abstract*—Big steps in the last years have been made in robotics. From mobile robots for home tasks to fully automatized systems in industrial environments.**

In the beginning, the main focus of robotics was to provide robotics solutions to tackle the necessity of improving both, productivity in repetitive tasks and safeguarding people in dangerous environments. Nowadays, following the advances in technology and industry 4.0, these objectives have changed to more demanding ones. These require flexible and autonomous intelligent solutions, i.e. systems capable of performing a variety of tasks with the minimum programming or system specifications. With the rise of Artificial Intelligence, novel algorithms have been developed, and let improve robotics systems capabilities by becoming more intelligent and autonomous.

The aim of this work is the development of an adaptative intelligent robotic system for physical interaction tasks. In this kind of task, the robot has a strong physical interaction with the environment, driving dynamical requirements to fulfill the task. To achieve this, a Three system framework made up of control, monitoring, and adaptative systems is proposed.

***Index Terms*—Robotics, physical interaction task, compliant controller, reinforcement learning, monitoring.**

environment characteristics, these controllers present a good performance. Notwithstanding working in non-structured or unknown environments, the tasks and environment characteristics are continuously changing, and due to that, force and position specifications are changing. For that reason, an adjustment in the controller parameters is needed. e.g. in a disassembly process of the recycling chain, where many types of products with different conditions arrive in the process, requires customized force or trajectories specifications.

Usually, fixed parameters are determined according to specific task requirements. If the environment changes, these parameters will cause inadequate results or poor performance. A new set of parameters are required to adapt the systems to the new task requirements. To achieve flexible and autonomous systems, the necessity of self-adaptation to face the tasks changes is needed.

Using compliant controllers, the robot is able to be compliant with the environment. Despite that, these control methodologies are restricted to the task characteristics that was used

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Control System for Robotic Interaction Tasks

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[1]Ikerlan Technology Research Centre (BRTA)
[2]University of the Basque Country (UPV/EHU)
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Abstract

Most current challenges in robotics are related to achieve fully automated processes in dynamical, unknown and non-structured applications, giving flexible and adaptable solutions. Some assembly and disassembly tasks present most of these challenges, where precise and careful requirements demands dynamical force specifications. For that reason, the development of intelligent systems with the capability of adaptability against different conditions or flexible components in autonomous ways are needed. A novel three-stage system where a ***compliant control*** with the combination of process ***monitoring*** and ***adaptability*** strategy is proposed in this work to face these challenges.

REVIEW PAPER (AUTONOMOUS ROBOTS)

An Overview of Robotic Systems for Physical Interaction Tasks: From Based Controllers to Intelligent Systems Approach.

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2nd Gorka Sorrosal, *Intelligent Control Department, Ikerlan Technology Research Centre*, Arrasate, Spain, email address or ORCID
3rd Aitziber Mancisidor, *Faculty of Engineering in Bilbao, University of the Basque Country (UPV/EHU)*, Bilbao, Spain, email address or ORCID

***Abstract*—Physical interaction are present in many relevant industrial tasks. Assembly, disassembly and machining operations are examples of its. Robotic systems provide flexible solutions to automatize this kind of tasks, nevertheless dotate the robot´s end effector with compliant behaviour to perform physical interaction tasks, drives the necessity of compliant force control architectures. In line with the level of complexity and flexibility of the task the robotic system face different challenges to achieve the requirements of the task. Starting with base compliant controller architectures as impedance and hybrid control,to face well-known tasks are discussed. Following, the necessity of increase the flexibility of these controllers to face more complex and demanding tasks, drives the development of monitoring systems in order to know the actual state of the task. Finally the necessity of autonomous systems for the tuning of the controller´s parameters are discussed, where classical and novel Artificial Intelligence (AI) techniques are used. In that way, trough this review paper an overview to different approaches to solve the challenges present in physical interaction tasks according the level of flexibility and autonomy required, are evaluated and discussed.**

***Index Terms*—Robot manipulation, Reinforcement learning, Force control, Adaptative control**

packing, painting and welding robotics lines can be found in factories [2]. These kind of tasks are known as free space tasks, and common position control strategies are suitable for the robot to fulfill the task requirements. Notwithstanding in the case of physical interaction tasks the needed to control the exerted force between the end effector of the robot and the environment makes position control not suitable for these tasks [1]. For that reason, to guarantee the correct force exerted between the robot end effector and the environment, compliant control architectures such as impedance control and hybrid control are used [3]. In these control architectures many parameters has to be set to guarantee the correct force during the task. To achieve this a precise model of both, the environment and the robot is needed [4]. The kinematics and dynamic description of the robot is well defined and have a strong theoretical background in the literature [5]–[7]. On the other hand, the environment and task description are widely studied, but the easiness or difficulty of the model depends directly on each case [1], [8]. In that way the controller´s

XLIV Jornadas de AUTOMÁTICA
2023 – ZARAGOZA

Paper: simulation Implementation in hybrid planning

ICRA

ICRA: comparisson analisys Simulation results

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This project is supported by the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No 955681

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¡Thanks!

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